CIE Independent Peer Review Report on the Stock Assessment of Pacific Bluefin Tuna

Sylvain Bonhommeau
IFREMER
Av. Jean Monnet
34 200 Sète, France
sylvain.bonhommeau@ifremer.fr

Contents

1 Executive summary

The 2012 Pacific bluefin tuna (PBF) stock assessment has been reviewed based on the report of the PBF working group (PBFWG), a list of critical papers, other critical documents listed in Appendix A, personal reading and the stock assessment model files that were kindly provided by the PBFWG. The present review report first reviews the background of PBF ecology, fisheries, and stock assessment. Second, in the summary of findings, the methods of the 2012 stock assessment are reviewed, as are the materials, the sensitivity of the findings to the assumptions, the relevance of the projections of the future PBF population used by the PBFWG and the research priorities to improve the stock assessment. Finally, a conclusion synthesizes the review of the stock assessment and provides the PBFWG with several recommendations for the next assessment.

This stock assessment report represents an excellent work that provides a fine example on how to present a complex assessment to a wide audience. The PBFWG used the best available data and knowledge of PBF biology, ecology, and fisheries. The modeling approach that was used (Stock Synthesis; Methot and Wetzel, 2013) is widely recognized, is largely used for tuna stock assessment and is particularly appropriate for the PBF. The results are reproducible and the assumptions are fully detailed and discussed. The sensitivity analysis demonstrates the robustness of the results. The projections of the future PBF population under different management scenarios are well designed and provide managers with potential outcomes in 2030. The PBFWG clearly details the strengths and the weaknesses of the data, where the model presented flaws and limitations and which hypotheses were the most influential. The report is generally well written and some grammatical editing comments are provided in Appendix C.

The model used for the 2012 PBF stock assessment was Stock Synthesis version 3 (SS; Methot and Wetzel, 2013) and is particularly suited for the PBF stock features and data. The PBFWG has a strong experience in running this kind of model and has used it for over four years. I note, however, that comparisons with other “simpler” models would reinforce the robustness of the results found here. It is also suggested to develop a Management Strategy Evaluation to aid in assessing the weaknesses of this model with respect to the data.

By examining structural and input sources of uncertainty, the PBFWG appears to have made admirable efforts to pre-empt criticism of the implementation of this assessment framework. The potential issues in the data were clearly exposed. The different choices of the PBFWG for data selection were always justified. My main concern regarding the data is that there is no fisheries-independent abundance index used in this stock assessment. Regarding the parameters, I am concerned that the values chosen for the natural mortality vector are particularly high for the age-2+, and have a major impact on the stock assessment reference points.

It is noteworthy that the PBFWG has achieved a very substantial amount of work on various subjects between the 2010 and 2012 stock assessments, such as the estimates of biological and fisheries parameters and data and the sensitivity of the modeling framework.

A sensitivity analysis was performed by comparing 20 different runs resulting from the combinations of different data selection and parameter values to a Representative Run that was derived from preliminary analysis of the PBFWG. The PBFWG demonstrated the general robustness of the results to the different assumptions and data. However, I think these analyses could be improved if other metrics, such as the fishing mortality vector and the total biomass, were also used to analyze the sensitivity of the SS model.
As the managers have not provided the PBFWG with biological reference points (BRPs), the group has proposed a suite of BRPs. Most Tuna Regional Fisheries Management Organisations use phase plot (F/F_{target} against SSB/SSB_{target}) as a BRP, and I would particularly suggest that the PBFWG uses it as well.

The PBFWG gave a detailed description of the projection specifications for projecting the SS model up to 2030 to estimate future trends in population levels and catch under four management scenarios. Results of projections are critical for management purposes and for managers and I think some aspects of this section should be further discussed and developed, such as the stability of catch and SSB despite the current high level of fishing mortality.

No research priorities are proposed by the PBFWG but I think this should be part of the stock assessment report. I propose several different research priorities here in relation to the summary of findings of the stock assessment.

2 Background

2.1 Biology and ecology

Pacific bluefin tuna (PBF; *Thunnus orientalis*) is a large scombrid fish species that can live more than 20 years (Hsu *et al.*, 2000, Shimose *et al.*, 2009). Like other bluefin species, PBF has the ability to thermoregulate its temperature, which enables it to tolerate wide temperature ranges. It is distributed across the subtropical to temperate North Pacific Ocean and is occasionally found in the South Pacific (off Western Australia, New Zealand and Gulf of Papua) or the subarctic frontal zone (Collette and Nauen, 1983, Kitagawa *et al.*, 2009). This species is mainly epipelagic, but it can be found seasonally inshore. It migrates between June and September along the coast of Baja California, Mexico and California. Tagging studies, conducted with conventional and archival tags, have revealed that some fish apparently remain their entire lives in the western North Pacific Ocean, while others migrate to the Eastern Pacific Ocean. These migrations begin mostly during the first and second years of life.

The only known spawning grounds are located in the eastern East China Sea between April to July, and in the Sea of Japan during July and August. To date, no population structure has been determined for this species and it is considered as a single stock. It reaches maturity at about 30 kg (age 3). Batch fecundity increases with length, from about five million eggs at 190 cm fork length (FL) to about 25 million eggs at 240 cm FL (Schaefer, 2001, Sawada *et al.*, 2005, Chen *et al.*, 2006, Collette, 2010). Maximum FL can reach 250 cm and recent studies cited in this stock assessment report have shown an interesting pattern of a decline in growth rate after 5 years (Shimose *et al.*, 2009, Shimose and Takeuchi, 2012). The natural mortality at age is thought to decrease with age. The

PBF Working Group (PBFWG) used values for natural mortality from 1.6 yr^{-1} at age 0 to 0.25 yr^{-1} at age 2+. These parameters were derived for younger ages (age 0 and 1) from tagging studies and for older ages from Pauly's equation.

2.2 Fishery

There is a long history of PBF fisheries operating in the western North Pacific by Japanese fisheries and in the East Pacific Ocean by US fisheries. The consistent reporting of these catches was implemented in the beginning of the 1950s by most of fishing nations. This period is therefore currently used by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) working group to assess the PBF stock. Catches of PBF reached almost 35,000 mt in the mid 1950s and were less than 10,000 mt by the end of the 1980s (Figs. 2.2-).

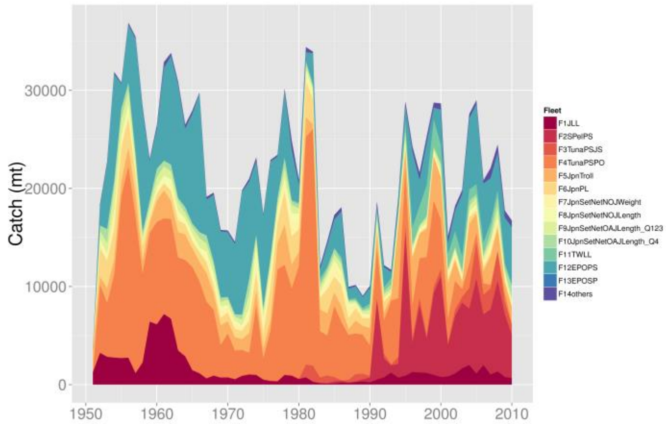

Figure 1: Historical annual catch (in metric tons) of Pacific bluefin tuna by fleet over 1952-2010 (data provided by the ISC stock assessment group).

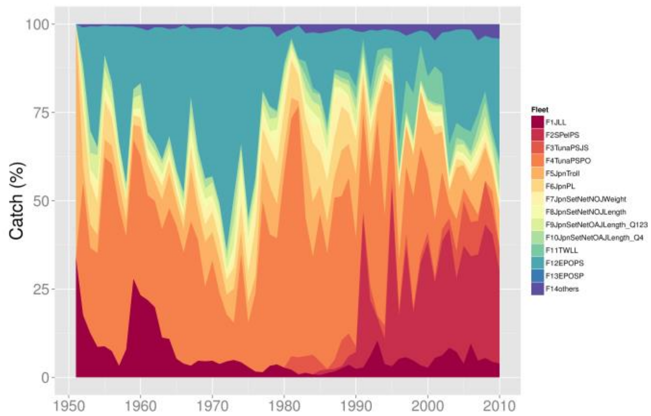

Figure 2: Historical annual catch (in %) of Pacific bluefin tuna by fleet over 1952-2010 (data provided by the ISC stock assessment group).

PBF are exploited by various gears in the western North Pacific Ocean, but most of the catches are taken by purse seiners and longliners. While catches were dominated by Japan and the US until the late 1990s, the two main fishing countries are currently Japan and Mexico. This change is mainly due to the development of aquaculture facilities for PBF in Mexico since 1999. These aquaculture farms were supported by the catch of a few Mexican purse seiners that had started to target PBF. During recent years, most of the catches have been transported to holding pens, where the fish are held for fattening and are later sold to sashimi markets. Lesser amounts of PBF are caught by recreational, gillnet, and longline gears. Seventy percent of the total catch is estimated to be comprised of fish below 100 cm in length, representing fish between 0 to 3 years of age (Fig.). PBF are caught during every month of the year, but most fish are taken between May and October (Fig.). The high-seas longline fisheries are directed mainly at tropical tunas, albacore, and billfishes, but small amounts of PBF are also caught.

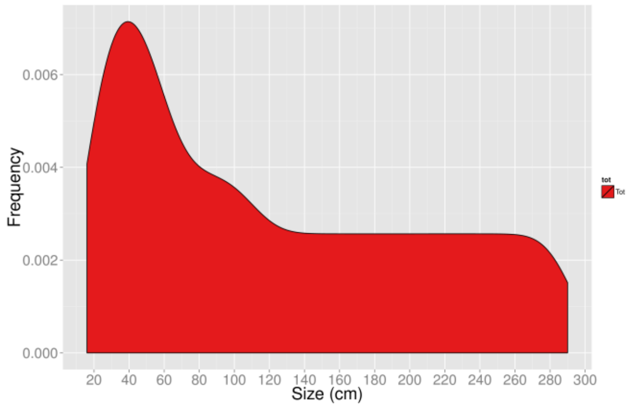

Figure 3: Size composition of the catch (cm) of Pacific bluefin tuna for all fleets (except Fleets 7 and 14) over 1952-2010 (data provided by the ISC stock assessment group).

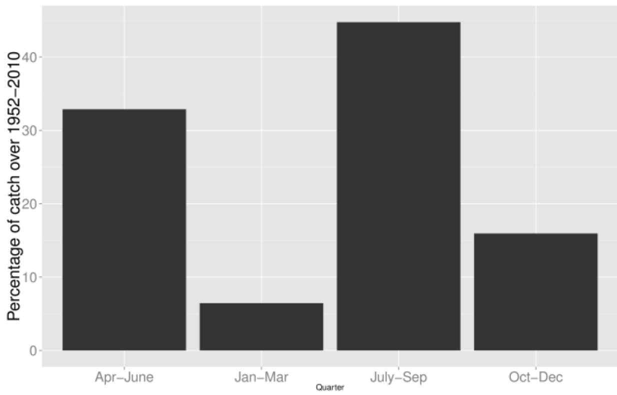

Figure 4: Percentage of total catch of Pacific bluefin tuna by season over 1952-2010 (data provided by the ISC stock assessment group).

2.3 Stock assessment

Although trends in recruitment do not show signs of decline, the Inter-American Tropical Tuna Commission (IATTC) stated in 1999 that "*[...] fishing has greatly reduced the abundance of mature bluefin in the Pacific Ocean [...]*" (IATTC, 1999). To assess the PBF stock, the working group uses a fully-integrated age-structured modeling framework: Stock Synthesis (SS) version 3 (Methot and Wetzel, 2013). SS uses a diversity of fisheries and survey data to calibrate population dynamics models. It is designed to accommodate both age- and size-structure in the general population and in multiple sub-areas of the stock. Selectivity can be defined as age-specific, size-specific in the observations, or size-specific with the ability to capture the major effects of size-specific survivorship. Some SS features include aging errors, growth estimations, and spawner-recruitment relationships. A management layer is also included in the model, allowing uncertainty in estimated parameters to be propagated to the management level. This facilitates a discussion of the risks of various possible management scenarios, including forecasts of possible annual catch limits.

The present assessment working group assumes that "*Pacific bluefin tuna are distributed across the North Pacific Ocean and considered as a single stock*" as there are thus far no compelling evidence or studies of a different population structure. The SS model has been used since 2008 by the PBFWG. This assessment includes 14 fisheries and uses seasons (quarters) as its time step for the period 1952-2010. The SS model is fitted to catch data, abundance indices, and size composition data. Five standardized abundance indices were included in the SS model. Four of them used Japanese and Taiwanese longline data to describe PBF adults, and one used Japanese troll fisheries data to describe recruitment. Quarterly size or weight composition data were used for each of the 14 fleets. The growth model parameters based on a von Bertalanffy model were fixed within the SS model. No fishery independent data were available. The assessment results were then used to project the dynamics of future stocks under different scenarios of fishing mortalities and fisheries regulations. No biological reference points (BRPs) are specified by managers, so the PBFWG give a suite of BRPs. The PBFWG developed a Representative Run (base-case model) for the assessment, and conducted some sensitivity analyses to evaluate impacts of different model configurations on spawning stock biomass (SSB) estimates.

Considerable research and analysis efforts have been undertaken in this stock assessment relative to 2010. Much advancement was achieved during preparatory meetings in 2011 and 2012 to improve the quality of the biological parameters and abundance indices to be used and to analyze the sensitivity of the model to the different parameters and data.

2.4 Review activities

The present review was realized between June 4 to June 14. The stock assessment report and related materials listed in Appendix A have been read. The PBFWG kindly provided me with the four different files to run the analyses. From these files, the quality of the data used and the classical tests on the outputs have been checked. Some sensitivity runs have been performed. The present review report has been written. Figures and LATEXcodes of the present report will be appended to the submission of this report. Some grammatical editing comments and suggestions are given in Appendix C. *R* (R Core Team, 2013) codes used for the figures of the present report are given in Appendix D.

The information in this review has been provided by way of review only. The author makes no representation, express or implied, as to the accuracy of the original information and accepts no liability whatsoever for either its use or any reliance placed on it. The files provided to me by the PBFWG have been deleted and no other copies have been made or distributed.

3 Summary of Findings

The general quality of the 2012 PBF stock assessment is excellent. The PBFWG have provided a detailed description of the weaknesses and strengths of the current assessment, have identified where further work would be beneficial, and have described the various choices made during the assessment. The presentation is clear though some repetition could be avoided (see Appendix C). The conservation measures proposed by the PBFWG are very clear and in agreement with the results. The PBFWG gives a wide range of potential BRPs whose consistency in message provides managers with informed and sound management options.

3.1 Review the assessment methods to provide recommendations on how to improve its application, and/or recommend other methods that would also be appropriate for the species, fisheries, and available data

SS has proven to be a powerful modeling framework to conduct stock assessment. It integrates different levels of complexity depending on the data available. SS is an adequate and reliable tool based on ADMB (Fournier *et al.*, 2012), which is particularly powerful for parameter estimation issues. In this stock assessment, SS is properly implemented given the data available, the specific life history of PBF, and the complexity of the fisheries. Using the SS model, the PBFWG developed a seasonal, length- and weight-based, age-structured forward population projection model to predict fishery data which were then compared with observed data in order to formulate likelihood functions for parameter estimation. Given the data, the available information about the fisheries and PBF life history and biology, very similar results could be obtained with a “simpler” approach, such as ADAPT (VPA-2BOX Gavaris, 1988). However, I firmly believe that the PBFWG has chosen a good model that has to ability to include the large amounts of new information which will be collected in the future.

The PBFWG does not use the capability of SS to integrate aging errors. Data on aging from several studies presented in this stock assessment report could be used for that purpose (Shimose *et al.*, 2009, Shimose and Takeuchi, 2012). I think the PBFWG could also consider using other stock assessment methods, such as a simple surplus production model to test the robustness of the results. To provide uncertainties about the results, the PBFWG could apply Bayesian estimation using the Monte Carlo Markov Chain algorithm from SS, if informative priors can be derived from the data.

The PBFWG has a very appropriate strategy for selecting a Representative Run from hypothesis testing. It makes the sensitivity of the model to alternative hypotheses very clear. This base-case model should be used for the next assessment to analyze the impact of the updated data and before establishing the new Representative Run. The likelihood profiles, such as those given in Teo and Piner (2012, Fig. 2), are very useful and should be included in the report. Moreover, the preliminary assessments of model sensitivity to the abundance indices and natural mortality (Teo, 2011; Teo and Piner, 2012) are also very interesting as they provide valuable exploratory tools for examining the implications of different choices and their potential interactions. These kinds of initiatives should be continued to save time on the parameterization and the calibration of the model during stock assessment meetings.

I would also strongly suggest the PBFWG to develop a Management Strategy Evaluation (MSE) framework to evaluate the performance of the SS model as it has been done for the southern bluefin tuna (Polacheck *et al.*, 1999) and is underway for the Atlantic bluefin tuna. Although the estimates of temporal trends are robust in the assessment, the absolute values of different key variables (e.g. SSB and F) are very sensitive to parameters such natural mortality (Figs. 3.2-; Teo, 2011). This sensitivity illustrates the importance to assess the model response to uncertainties in the data. The MSE framework could include (*i*) an operating model that represents alternative plausible hypotheses about stock and fishery dynamics, (*ii*) management procedures or a management strategy that is the combination of the available pseudo-data, the stock assessment used to derive estimates of stock status and the management model or Harvest Control Rule, and (*iii*) an observation error model that describes how simulated fisheries data, or pseudo-data, are sampled from the operating model.

3.2 Evaluate the assessment model configuration, assumptions and input parameters (fishery, life history, and spawner recruit relationships) to provide recommendations on how to improve: the use of data, specification of fixed input parameters, and specification of model configuration

The PBFWG has used the best data available and the model configuration and assumptions are very well detailed in the report. Globally, the assessment modeling framework is appropriate and very well-executed. The PBFWG has made this report very clear to understand the assumptions for data and parameter selection.

Fishery data In any stock assessment, the quality of fishery data and derived abundance indices are of primary importance. The PBFWG has dedicated a substantial amount of time to justify their choices for data selection and analyses. Globally, these choices are valid and the sensitivity to the data used ensures the robustness of the results. The use of quarters as time steps is consistent with seasonality of some fisheries and particularly appropriate for an SS model. It would be informative to include maps of the distribution of the catch by fleet and by quarter (e.g. colored pie charts). The PBFWG has removed purse seiner-derived abundance indices due to the difficulty in assessing the fishing effort. This gear, however, represents most of the catch and it would be interesting to develop a method to provide an estimate of the fishing effort, including searching time. In particular, state-space models using semi-hidden Markov chains could be developed to discriminate the route, the search and the catch states from geolocation of fishing vessels and log-book data. I acknowledge that this is a substantial amount of work, but it could provide the PBFWG with a reliable fishing effort and thus a purse seiner abundance index.

Catch are extrapolated for some fisheries and correspond to declaration by countries. I think it would help the reader to have the catch per gear and per country as a percentage of the total catch to really see the patterns of contribution (e.g. Fig. of the present report). Although this topic is sensitive, it would be informative to estimate the reliability of the catch declaration and assess potential under-reporting. This could be done by estimating the catch rate of specific fleets over a period and multiplying this catch rate (assumed to be constant over the period) by the number of fishing vessels over another period to check if the catch data are in agreement with these estimates.

The selectivity patterns for each fleet are estimated from size composition within SS. The PBFWG defined several *a priori* shapes for the selectivity pattern and after a sensitivity analysis, the appropriate pattern (dome-shaped or sigmoid) enabled consistent results and the convergence of SS. I would suggest that the PBFWG compare the results with the selectivity patterns estimated from a catch-curve analysis, such as that developed by Restrepo *et al.* (2007).

The catchability (q) for each abundance index was estimated within SS. Potential changes in q were approximated by assuming larger observation errors in the abundance indices. The PBFWG also accounted for changes in q within SS by estimating q over different periods. I also suggest testing the sensitivity of the result to different fixed rates of the increase in q. For example, this is done for tropical tuna purse seiner fisheries where q increases by 5% per year.

Although the method is described in the related papers listed in Appendix A, a short description of the method used to standardize the Catch Per Unit Effort (CPUE) should be described in the report. Whether CPUE is a good abundance indicator may be questionable even if it is standardized. On a longer perspective, the PBFWG should also think about collecting fishery-independent abundance indices, which are key to having reliable abundance indices and would avoid the problems linked to CPUE (see section 4.5).

Natural mortality vector The PBFWG has chosen to use a fixed natural mortality vector (M) based on tagging studies for age-0 and age-1 and Pauly's equation for subsequent ages. The natural mortality vector is one of the most critical parameters for the estimates of fishing mortality (since it is derived from the Baranov equation) and reference points. I found the 0.25 yr^{-1} value particularly high compared to mortality rates used for other bluefin tuna species. Moreover, Whitlock *et al.* (2012) have estimated the values of M for PBF aged 5 and above at 0.15 yr^{-1} (standard deviation = 0.10) based on tagging data. I analyzed the sensitivity of the stock assessment results (SSB, R, F) when applying the 0.15 yr^{-1} natural mortality and compared this to the Representative Run (Figs. 3.2-) as in Teo (2011). Although I agree with the PBFWG that the impact on SSB and R is not critical, I think it has a significant impact on the fishing mortality estimates and thus on the reference points (Fig.). I would suggest that the PBFWG discuss this issue in the report (and the results of Whitlock *et al.* (2012)) and include the results of Teo (2011). Substantial effort should be made to account for the uncertainty around natural mortality vectors and its impact on BRPs.

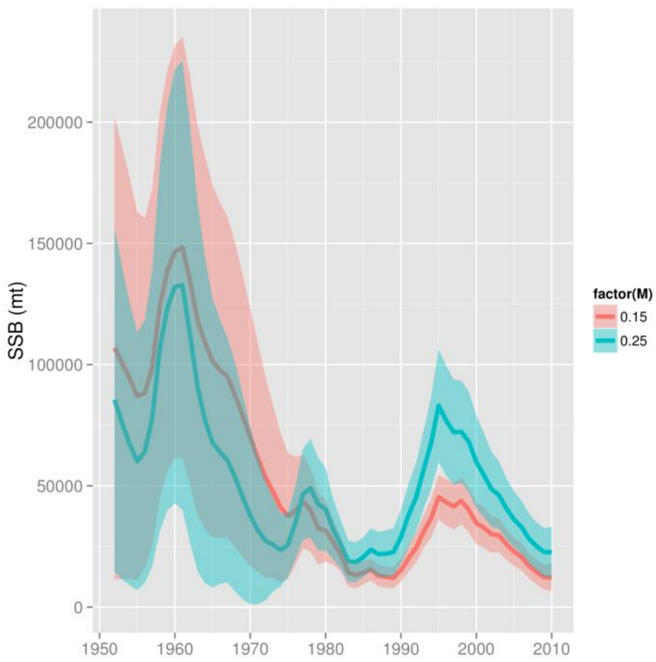

Figure 5: Influence of the natural mortality vector on the estimates of spawning stock biomass (SSB) over 1952-2010 (data provided by the ISC stock assessment group). The 0.25 yr^{-1} for age-2+ is currently used by the Pacific Bluefin Working Group (PBFWG) and the value of 0.15 yr^{-1} corresponds to the estimates of Whitlock *et al.* (2012).

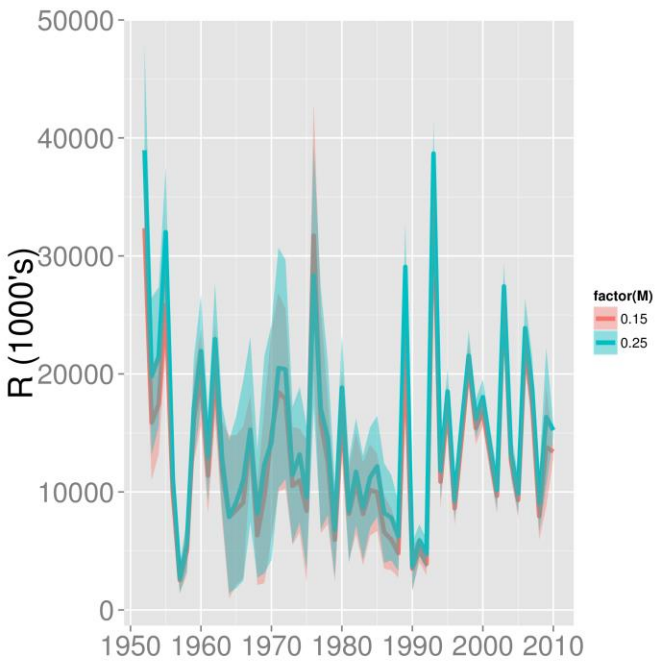

Figure 6: Influence of the natural mortality vector on the estimates of the recruitment over 1952-2010 (data provided by the ISC stock assessment group). The 0.25 yr^{-1} for age-2+ is currently used by the Pacific Bluefin Working Group (PBFWG) and the value of 0.15 yr^{-1} corresponds to the estimates of Whitlock *et al.* (2012).

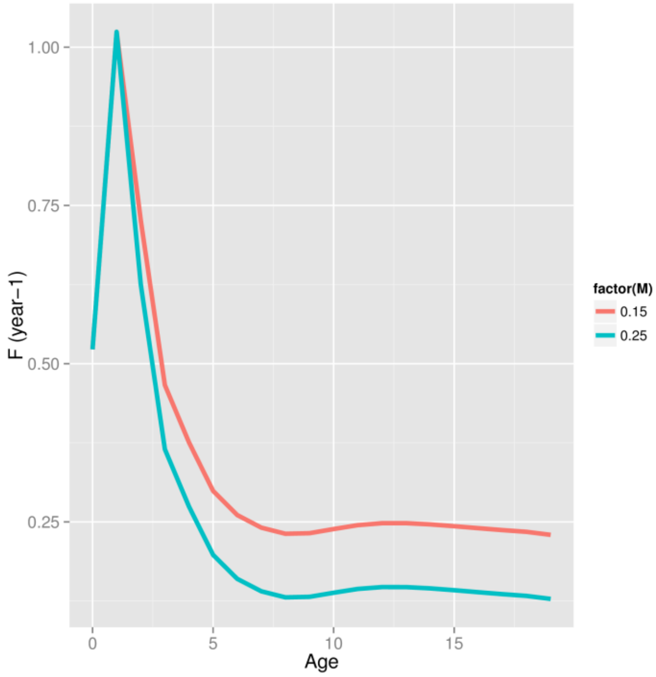

Figure 7: Influence of the natural mortality vector on the estimates of the fishing mortality over age 0 to 19 (data provided by the ISC stock assessment group). The 0.25 yr^{-1} for age-2+ is currently used by the Pacific Bluefin Working Group (PBFWG) and the value of 0.15 yr^{-1} corresponds to the estimates of Whitlock *et al.* (2012).

Growth Growth parameters are estimated outside the SS and are based on results from Shimose and Takeuchi (2012). Other parameters, such as A_2, are manually tuned. It is not clear in the report what criteria have been used to determine A_2=3, and I suggest that a short discussion on this be included. The internal estimation of the growth model within the SS model allows for a good model fit. However, I am not certain that the complexity of this option is appropriate for the current assessment. A simplification of growth parameters could be investigated for the next assessment.

Sexual dimorphism in size-at-age and longevity is suggested for the PBF by Shimose and Takeuchi (2012). This implies differences in growth, maturation and natural mortality between females and males. More studies need to be done to test this hypothesis since apparent issues exist in age reading and between the estimated and observed lengths of age-0 fish. If there is more evidence of sexual dimorphism, a sex-specific stock assessment model needs to be considered.

Maximum age The PBFWG used a maximum age of 20 to "*avoid biases associated with the approximation of dynamics in the accumulator age*". While I agree with this statement, it also increases the number of parameters to be estimated. As a sensitivity analysis, the PBFWG could assess the impact of setting the maximum age to 10 years, for instance.

Steepness parameter The steepness parameter (h) is critical for stock assessment outputs. A sensitivity analysis has been performed to estimate the impact of two alternative values for h (the h of the Representative Run is set to 0.999 while values of 0.8 and 1.0 have been tested). Another option that was tried in this assessment was to employ the approach developed by Mangel *et al.* (2010) to estimate *h* (Iwata, 2012 and Iwata *et al.*, 2012). However, due to uncertainty in the natural mortality during first years, the *h* estimates were close to 1 and not different to the *h* currently used. However, for an *h* of 0.8, the model did not converge. It would be informative to have some explanations about this non-convergence. For the Representative Run, the value of *h* implies that there is basically no stock recruitment relationship. Given the low SSB for the recent period, the 0.8 value for *h* would imply a low recruitment, which does not fit with the data (i.e., the CPUE index of the troll fisheries). I think it is important to discuss (or solve) this issue since *h* is very influential on the outcome. Perhaps, it is possible to tune the recruitment penalty function for that purpose.

3.3 Provide recommendations on improving the treatment of assumptions (e.g. sensitivity analyses) and description of uncertainty in estimates of stock dynamics and management quantities (e.g. reference points)

The PBFWG have performed a large number of preliminary analyses before the 2012 stock assessment meeting to develop a Representative Run. The group then performed sensitivity analyses on the CPUE data, the effective sample size, the size composition, the size selectivity, and the biology. Combining the different assumptions about these inputs, 20 different runs were compared to the Representative Run. The SSB and the negative log-likelihood were used to analyze the sensitivity of the SS model. Globally, the sensitivity analysis of the 20 different runs indicates highly robust results. Hence, the sensitivity analyses conducted appear thorough and sufficiently complete to provide the necessary confidence in the model outputs.

Sensitivity analysis The sensitivity analysis results from a very good knowledge of PBF stock and fisheries and seems appropriate for the stock assessment. A variety of combinations have been tested to investigate potential changes in the results and the PBFWG gives fully-detailed reasoning for these specifications. Although this expert approach is relevant, it would be interesting to use a more systematic design of the sensitivity analyses and test a larger number of combinations of parameter values. Although it would be unrealistic to analyze all combinations of the different parameter values some combinations could be removed due to correlations between parameters (e.g. *h* and *M*). Even a limited number of values could enable the PBFWG to have some model diagnoses and determine if the model assumptions have been violated. In particular, I would suggest that the PBFWG evaluate the residuals patterns with respect to the distribution hypotheses and discuss whether the different parameters are significant with respect to their coefficients of variation (CVs). For instance, the residual patterns of the size composition of the different fleets do not seem randomly distributed.

Uncertainty in estimates of stock dynamics The outputs of the sensitivity analysis enable the PBFWG to test for a major part of the uncertainty of the modeling approach. The uncertainty of the data and the parameters are integrated within the SS procedures and results were presented to illustrate the associated uncertainty on the SSB and recruitment (R). The bootstrapping method used in the stock assessment enabled the PBFWG to assess the sensitivity of the model to initial conditions. The parameter estimation procedure and results show a relative confidence in the current estimates of

SSB and R. It is noteworthy that the past SSB estimated from the Representative Run is substantially different from the median SSB from the bootstraps. The reason for this phenomenon is not clear and it would be informative to understand. I think that the impact of uncertainties should be explored further and extended to the fishing mortality-at-age estimates. A clear demonstration of the need for this is shown by the uncertainty around *M* that is not made clear when examining just SSB or R.

Another issue, the evolution of Fs-at-age over 1952-2010 exhibits an odd peak in the beginning of the 1990s and I suggest a discussion on the potential explanations for this. I also suggest including the total stock biomass in the sensitivity analyses as juvenile abundance can also have large errors. This effect can be very important due to the high fishing effort on these ages.

The retrospective analysis shows no signs of bias and variations in SSB, R, and F after the removal of the last years are relatively small. As usual for age-structured models, a systematic bias is observed for the last year of recruitment.

Reference points As managers have not defined the reference points, the PBFWG has proposed eight ratios of the geometric mean of F-at-age over 2007-2009 and 2002-2004 to classical fishing mortality targets. The PBFWG also proposes the depletion ratio (ratio of SSB in 2010 to unfished SSB). There is a high consistency in the results between the different runs. Globally, these reference points show a high overfishing of PBF and indicate that the stock is overfished. These results are very important for management purposes and are clearly explained. The situation of the PBFWG is delicate as no target reference points have been defined. However, providing the full suite of BRPs can blur the message. I would suggest that the PBFWG select the primary BRPs, as used by other tuna working groups, i.e., $F_{0.1}$, and F_{Max}. I also suggest that the PBFWG provide reference points for SSB in addition to those for F, such as $SSB_{F0.1}$ and SSB_{FMax}. These metrics complement the stock status information by including the notion of under-, fully-, or over-fished statuses as compared to the F-based reference points. To go further, I would strongly suggest that the PBFWG include phase plots (i.e., the so-called Kobe plot) that represent F/F_{target} against SSB/SSB_{target} which are widely used by other Tuna Regional Fisheries Management Organizations. These plots can be difficult as the target reference points are not defined. However, some examples, such as $F_{0.1}$, which is a conservative reference point, could be taken to illustrate the usefulness of these plots.

3.4 Provide recommendations on improving the adequacy, appropriateness, and application of the methods used to project future population status

Projections are always a difficult task in stock assessments since errors propagate and can have critical consequences in management decisions. The PBFWG gave a detailed description of the projection specifications and projected the SS model using *ssfuture R* package. The methods used to project future population levels and catch up to 2030 are appropriate and well described. Four scenarios about the fishing mortality and the potential catch limitations are tested. The future fishing efforts that were used were the geometric mean of the Fs-at-age over either 2007-2009 or 2002-2004. Different catch limitations were proposed for the four purse seine fisheries. Three hundred bootstraps were performed followed by 20 stochastic simulations to account for the different sources of uncertainty. No stock-recruitment relationships were defined, which corresponds to the value of 0.99 for *h* in the Representative Run.

The projections indicate that there is a low probability of recovery if the fishing effort remains at current levels and no catch limitations are set. If the fishing effort is reduced to the 2002-2004 level, SSB is projected to reach 41,000 mt by 2030. If the fishing effort remains at current levels, but catch limitations are set, the SSB is projected to reach 50,000 mt by 2030. Finally, if fishing effort is reduced to the 2002-2004 level and catch limitations are set, the SSB is projected to reach 83,000 mt by 2030. I have two concerns regarding these results. First, the projections using the current fishing mortality levels and no catch limitations, i.e., "status quo", predict that SSB will be constant and at the same current level up to 2030. Given the very high current fishing mortalities, it seems odd that the SSB and catch could be maintained without any sign of decline in the total stock biomass. My concern is that these projections could give a misleading message to managers.

These projection results could stem from the fact that there is no stock recruitment relationship included in the projections and that R is drawn randomly from the past-estimated recruitment. In other words, the recruitment overfishing is not allowed in this configuration. The combination of this specification and the high fishing mortality for first ages can theoretically maintain a constant SSB and catch as the population dynamics model reaches an equilibrium. The PBFWG should discuss this issue to avoid misinterpretation by managers. An option could be to group SSBs by levels (e.g. High or Low) and estimate the frequency of the corresponding recruitment. Depending on the SSB level, the recruitment could be randomly drawn from these different distributions.
My second concern is that none of the proposed conservation measures enable the stock to recover by 2030. This is not an issue by itself since this is scientific advice and it is the result of the best current knowledge. However, the PBFWG should discuss further these projections, and put these absolute numbers into context. Unfished SSB is estimated at 633,468 mt in the Representative Run. Using the simple rule of thumb: SSB_{MSY}=40% of unfished SSB, it means that SSB_{MSY}=253,000 mt. This means that SSB_{2030}/SSB_{MSY}=0.33. **The SSB in 2030 would be only 33% of the SSB at MSY for the most conservative scenario proposed by PBFWG**. These numbers are very alarming and I think the PBFWG should clearly state this issue in the report.

In addition, the PBFWG could also investigate size limitations for PBF catch, especially to forbid catch of fish that have not reached maturity size or weight. I am aware that the fisheries are targeting these ages and of the potential economic issues linked with this kind of conservation measures, but it could be informative for managers to have information on the recovery time of stocks with Fs at age 0-3 equal to zero for projections.

3.5 Suggest research priorities to improve the stock assessment including data, life history and modeling

I am not familiar with the functioning of ISC and the format of this stock assessment but I think it would be useful that the PBFWG includes a section in their report about research priorities to improve the stock assessment. This could be transmitted to both the IATTC and WCPFC. I would also encourage the PBFWG to exchange with the Atlantic bluefin tuna (ABFT) working group of the International Commission for the Conservation of

Atlantic Tunas (ICCAT) as fisheries, biology, and ecology of PBF and ABFT are very similar. Therefore, research questions and approaches to tackle them can be easily shared. In addition, there is currently a Research Program that is led by ICCAT and funded by the European Commission that has objectives to improve knowledge of key issues in ABFT ecology, biology and harvest and to improve the stock assessment. These objectives could be helpful to inform the direction of research priorities for PBF. Considering these points, and after having reviewed the PBF stock assessment, I have several research propositions that could be investigated to improve the stock assessment. For each following subsections, the propositions are ranked from short to long-term needs/impacts.

Fisheries data

- Develop a modeling approach to estimate purse seiner fishing effort (e.g. based on geolocation of fishing vessels) and calculate an abundance index for the purse seine fisheries;
- Evaluate the quality of catch data (e.g. using catch rates per fleet over a period and multiplying them by the number of fishing vessels over another "suspicious" period to conduct a sensitivity analysis to evaluate potential impacts of under-estimating landing data on the assessment);
- Develop a fisheries-independent abundance index. All "abundance indices" in this report are CPUEs. I strongly suggest that the PBFWG think about this fisheries-independent index. For instance, such indices have been developed using aerial surveys for the southern bluefin tuna and ABFT with relatively low costs compared to surveys at sea.

Biological data

- A substantial research effort should be made to focus on the estimate of natural mortality, especially regarding its critical influence on the stock assessment results. Tagging activities should continue and analyses of the tagging data (archival and electronic) should also be continued.
- The modeling approach and data collection should be carried out to provide the PBFWG with a robust growth curve and uncertainty with a focus on the age-0 issue. A sex-specific approach and spatial analysis would be particularly interesting given the possibilities of the SS model.
- A specific focus on reproduction would provide critical information for the stock assessment. In particular, it could be critical to know whether PBF skips spawning and if yes, the percentage of the population that do so. Research on the maturity could help to improve the maturity-at-age vector and help define the minimal age/size that could be caught. Potential maternal effects could also be investigated and would have important repercussions in terms of management. Such maternal effects could be investigated using a modeling framework such as the Dynamic Energy Budget (Kooijman, 2010) that has already been developed for this species (Jusup *et al.*, 2011).

Ecology

- Collect data to determine if there is a population structure for PBF. This would have a major impact on management decisions. These data could include genetic, contaminant or microchemistry studies.
- Continue tagging activities to better understand the trans-Pacific migration, the migration rates between areas, and the residency time in certain areas.
- Continue research efforts to investigate the impact of environment on the PBF distribution and the population dynamics, including habitat modeling approaches to investigate the impact of potential changes in environment on the PBF habitat, or studies of larval survival and its variability using Lagrangian modeling.

Methods

- Compare the results of the current assessment with other simple stock assessment frameworks (i.e., surplus production model and classical VPA) to ensure the robustness of the results.
- Develop a sensitivity analysis using a large range of combinations of data and parameters. This could be achieved using cluster computers with an appropriate design and specific methods such as Gauchi *et al.* (2010).
- Develop a MSE framework based on our understanding and available information of PBF biology and fishery. Use the MSE framework to evaluate the performance of the SS model used in the PBF stock assessment.

4 Conclusions and Recommendations

Globally, the 2012 PBF stock assessment used the best of available data and knowledge to conduct their analysis using a powerful and widely-recognized stock assessment model: Stock Synthesis (Methot and Wetzel, 2013). While some points could be discussed and some small edits could be made to improve clarity (see Appendix C), the PBFWG has fully described the stock assessment procedure and assumptions with a critical view. Results are reproducible and this is an excellent assessment that provides a fine example of how to present a complex assessment to a wide audience.

4.1 Review the assessment methods to provide recommendations on how to improve its application, and/or recommend other methods that would also be appropriate for the species, fisheries, and available data

The SS model (Methot and Wetzel, 2013) used for the 2012 PBF stock assessment is particularly suited for the PBF stock features and data. The PBFWG has a strong experience in running this kind of model and has used it for more than four years.

Following the Summary of Findings, I would recommend to:

- compare the results of the current assessment with other simple stock assessment frameworks (i.e., a surplus production model and a classical VPA) to ensure the robustness of the results;
- provide the likelihood profiles as in Teo and Piner (2012);
- use the Bayesian possibilities offered by SS; and

- develop a MSE to assess the SS model.

4.2 Evaluate the assessment model configuration, assumptions, and input parameters (fishery, life history, and spawner recruit relationships) to provide recommendations on how to improve: the use of data, specification of fixed input parameters, and specification of model configuration

By examining the structural and input sources of uncertainty, the PBFWG appears to have made considerable efforts to pre-empt criticism of their implementation of this assessment framework. The PBFWG has used the best available data and the model configuration and assumptions are very well detailed in the report. Globally, the assessment modeling framework is appropriate and very well executed. The assumptions for data and parameter selection made by the PBFWG are very clear in this report.

Following the Summary of Findings, I would recommend to:

- estimate the fishing effort of the purse seiner fisheries that represent most of the catch;
- analyze all sources of information available to reduce the uncertainty of the natural mortality vector, especially for the age-2+;
- solve the problem of the growth curve at age-0;
- investigate the effect of setting the maximum age at age-10; and
- investigate the failure of the run with a steepness of 0.8.

4.3 Provide recommendations on improving the treatment of assumptions (e.g. sensitivity analyses) and description of uncertainty in estimates of stock dynamics and management quantities (e.g. reference points)

The treatment, given the sensitivities of the parameters, was adequate to generate confidence that the model outputs were internally consistent. The hypotheses underlying the 20 different runs were clearly stated and justified. Globally, the sensitivity analysis of the 20 different runs shows a high robustness of the results. Hence, the sensitivity analyses conducted appear thorough and sufficiently complete to provide the necessary confidence in the model outputs.

Following the Summary of Findings, I would recommend to:

- develop a sensitivity analysis using a large range of combinations of data and parameters. This could be achieved using cluster computers with an appropriate design and specific methods such as Gauchi *et al.* (2010);
- evaluate and discuss the residuals patterns with respect to the distribution hypotheses and discuss whether the different parameters are significant with respect to their CVs;
- include Fs-at-age and total biomass as an assessment of the sensitivity analyses;
- include reference points based on SSB in addition to F; and

- follow the general agreement between Tuna Regional Fisheries Management Organisations in using phase plots (F/F_{target} against SSB/SSB_{target}).

4.4 Provide recommendations on improving the adequacy, appropriateness, and application of the methods used to project future population status

The PBFWG gave a detailed description of the projection specifications and projected the SS model using *ssfuture R* package. The methods used to project future population levels and catch up to 2030 are appropriate and well described.

Following the Summary of Findings, I would recommend to:

- clarify why SSB and catch remain constant for scenario 1, even though the fishing mortalities are particularly high and should lead to a decline in the population. The PBFWG should discuss this issue to avoid misinterpretation by managers;
- emphasize that none of the scenarios lead to a recovery in 2030 and illustrate that even when projecting with the most conservative scenario, the SSB would be less than one third of SSB_{MSY}; and
- investigate for illustrative purposes the time-to-recovery with Fs at age 0-3 equal to zero for the projections.

4.5 Suggest research priorities to improve the stock assessment including data, life history and modeling

It would be useful that the PBFWG includes a section about research priorities to improve the stock assessment. I would also encourage the PBFWG to exchange with the Atlantic bluefin tuna (ABFT) working group of the International Commission for the Conservation of Atlantic Tunas (ICCAT).

Following the Summary of Findings, I would recommend to:

- develop a fisheries-independent index;
- develop a substantial effort to estimate the natural mortality vector;
- collect data to investigate the potential population structure of PBF; and
- use the MSE framework to evaluate the performance of the SS model developed for the PBF stock assessment

References

Chen, K.-S., Crone, P., and Hsu, C.-C. 2006. Reproductive biology of female Pacific bluefin tuna *Thunnus orientalis* from south-western North Pacific Ocean. *Fisheries Science*, **72**(5): 985–994.

Collette, B.B. 2010. *Reproduction and sexuality in marine fishes: patterns and processes*. Berkeley, CA: University of California Press. pp. 21–63. Chap. Reproduction and development of epipelagic fishes, pp. 21–63.

Collette, B.B., and Nauen, C.E. 1983. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. *FAO Species Catalogue*, **125 FAO Fish. Synop.**(2): 137.

Fournier, D.A., Skaug, H.J, Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M.N., Nielsen, A., and Sibert, J. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. *Optim. Methods Softw.*, **27**: 233–249.

Gauchi, J.P., Lehuta, S., and Mahévas, S. 2010. Optimal Sensitivity Analysis under Constraints: Application to fisheries. *Procedia - Social and Behavioral Sciences*, **2**(6): 7658 – 7659. Sixth International Conference on Sensitivity Analysis of Model Output.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. *Can. Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc.*, **88/29**: 12 pp.

Hsu, C.C., Liu, H.C., Wu, C.L., Huang, S.T., and Liao, H.K. 2000. New information on age composition and length–weight relationship of bluefin tuna,*Thunnus thynnus*, in the southwestern North Pacific. *Fisheries Science*, **66**: 485–493.

IATTC. 1999. *Background paper 8, 63rd Meeting of the IATTC, 8-10 June, 1999*. IATTC, La Jolla, CA, USA. Chap. Assessment of bluefin tuna in the eastearn Pacific Ocean.

Jusup, M., Klanjscek, T., Matsuda, H., and Kooijman, S.A.L.M. 2011. A Full Lifecycle Bioenergetic Model for Bluefin Tuna. *PLoS ONE*, **6**: e21903.

Kitagawa, Takashi, Kimura, Shingo, Nakata, Hideaki, Yamada, Harumi, Nitta, Akira, Sasai, Yoshikazu, and Sasaki, Hideharu. 2009. Immature Pacific bluefin tuna, Thunnus orientalis, utilizes cold waters in the Subarctic Frontal Zone for trans-Pacific migration. *Environmental Biology of Fishes*, **84**(2): 193–196.

Kooijman, S.A.L.M. 2010. *Dynamic Energy Budget theory for metabolic organisation*. Cambridge University Press, Great Britain.

Mangel, M., Brodziak, J., and DiNardo, G. 2010. Reproductive ecology and scientific inference of steepness: a fundamental metric of population dynamics and strategic fisheries management. *Fish and Fisheries*, **11**: 89–104.

Methot, R.D.Jr., and Wetzel, C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research*, **142**: 86–99.

Polacheck, T., Klaer, N. L., Millar, C., and Preece, A. L. 1999. An initial evaluation of management strategies for the southern bluefin tuna fishery. *ICES Journal of Marine Science: Journal du Conseil*, **56**(6): 811–826.

R Core Team. 2013. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0.

Restrepo, V., Ortiz de Urbina, J.M., Fromentin, J.-M., and Arrizabalaga, H. 2007. Estimates of selectivity for eastern Atlantic bluefin tuna from catch curves. *Collect. Vol. Sci. Pap. ICCAT*, **60(3)**: 937–948.

Sawada, Y., Okada, T., Miyashita, S., Murata, O., and Kumai, H. 2005. Completion of the Pacific bluefin tuna *Thunnus orientalis* (Temminck et Schlegel) life cycle. *Aquaculture Research*, **36**: 413–421.

Schaefer, K. M. 2001. *Tunas: Ecological Physiology and Evolution*. Academic Press. pp. 225–270. Chap. Reproductive biology of tunas, pp. 225–270.

Shimose, T., and Takeuchi, Y. 2012. Updated sex specific growth parameters for Pacific bluefin tuna *Thunnus orientalis*. *ISC/12-1/PBFWG/12*.

Shimose, T., Tanabe, T., Chen, K.S., and Hsu, C.C. 2009. Age determination and growth of Pacific bluefin tuna, *Thunnus orientalis*,off Japan and Taiwan. *Fisheries Research*, **100**: 134–139.

Teo, S. 2011. Sensitivity of estimated spawning biomass to natural mortality assumptions in Pacific bluefin tuna assessments. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 6-13 January 2011. *Shimizu, Shizuoka, Japan.*, **ISC/11/PBFWG/10**: 7p.

Teo, S., and Piner, K. 2012. Preliminary population dynamics model of Pacific bluefin tuna.*ISC/PBFWG-3/8*, http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_08_Teo_Piner_Preliminary_PBF_population_dynamics_model.pdf.

Whitlock, R.E., McAllister, M.K., and Block, B.A. 2012. Estimating fishing and natural mortality rates for Pacific bluefin tuna (*Thunnus orientalis*) using electronic tagging data. *Fisheries Research*, **119–120**: 115 – 127.

5 Appendix A

List of critical papers for PBF stock assessment in 2012

Selected Working Papers at ISC/12/PBFWG workshop in Jan-Feb. 2012

Kanaiwa, M., Tsuruoka, I., Shibano, A., Shimura, T., Uji, R., Ishihara, Y., and Takeuchi, Y. 2012. Update of estimated catch at size by Purse Seiner in Japanese sea. ISC/12/PBFWG-1/7
Available: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC12-1PBFWG07_Kanaiwa.pdf

Ichinokawa, M., and Takeuchi, Y. 2012. Standardized CPUE of North Pacific bluefin tuna caught by Japanese coastal longliners: updates until 2011. ISC/PBFWG-1/8
Available: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC12-1PBFWG08_ichinokawa.pdf

Ichinokawa, M, K. Oshima, and Y. Takeuchi. 2012. Abundance indices of young Pacific bluefin tuna, derived from catch-and-effort data of troll fisheries in various regions of Japan. ISC/12/PBFWG-1/11
Available: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC12-1PBFWG11_ichinokawa.pdf

T. Shimose and Y. Takeuchi. 2012. Updated sex specific growth parameters for Pacific bluefin tuna *Thunnus orientalis*. ISC/12/PBFWG-1/12
Electronic copy provided.

Iwata, S.,K. Fujioka, H. Fukuda, and Y. Takeuchi. 2012. Reconsideration of natural mortality of age -0 Pacific bluefin tuna and its variability relative to fish size. ISC/12/PBFWG-13
Electronic copy provided.

Fujioka, K., Ichinokawa, M., Oshima, K., and Takeuchi, Y. 2012. Re-estimation of standardized CPUE of Pacific bluefin tuna caught by Japanese offshore longline fisheries operated during 1952-1974. 2012. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting,31 January 7 February 2012, La Jolla, California, USA. ISC/12/PBFWG1/10: 13p. Available at:
http://isc.ac.affrcgo.jp/pdf/PBF/ISC12_PBF_1/ISC12-1PBFWG10_Fujioka.pdf

Mizuno, A., Ichinokawa, M., Oshima, K. and Takeuchi, Y. 2012. Estimation of length compositions on Pacific bluefin tuna caught by Japanese longline fishery. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 31 January 7 February 2012, La Jolla, California, USA. ISC/12/PBFWG1/01: 24p. Available at: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC121PBFWG01_Mizuno.pdf

Oshima, K., Kai, M., Iwata, S and Takeuchi, Y. 2012a. Reconsideration of estimation of catch at size for young Pacific bluefin tuna caught by Japanese small pelagic fish purse seine fisheries. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group

Meeting, 31 January 7 February 2012, La Jolla, California, USA. ISC/12/PBFWG1/02: 21p. Available at:
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC12- 1PBFWG02_Oshima.pdf

Kai, M. and Takeuchi, Y. 2012. Update and re- examination of the estimation of catch at size of Pacific bluefin tuna *Thunnus orientalis* caught by Japanese set- net fishery. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 31 January- 7 February 2012, La Jolla, California, USA. ISC/12/PBFWG- 1/05: 34p. Available at:
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC12- 1PBFWG05_kai.pdf

Selected Working Papers from the ISC/12/PBFWG workshop in Nov. 2012

Iwata, S. 2012. Estimate the frequency distribution of steepness for PBF. ISC/12/PBFWG-3/1
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_01_Iwata.pdf

Aires-da-Silva, A., and Dreyfus, M. 2012 A critical review on the PBF length-composition data for the EPO purse seine fishery with new data collected at Mexican PBF pen rearing operations. ISC/12/PBFWG-3/2
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_02_daSilva&Dreyfus_2012rev.pdf

Fukuda, H., Kanaiwa, M., Tsuruoka, I., and Takeuchi, Y. 2012. A review of the fishery and size data for the purse seine fleet operating in the Japan Sea (Fleet 3). ISC/12/PBFWG-3/3
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_03_Fukuda.pdf

Oshima, K., Mizuno, A., Ichinokawa, M., Takeuchi, Y., Nakano, H., and Uozumi, Y. 2012. Shift of fishing efforts for Pacific bluefin tuna and target shift occurred in Japanese coastal longliners in recent years. ISC/12/PBFWG-3/5
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_05_Oshima.pdf

Ichinokawa, M., and Takeuchi, Y. 2012. Estimation of coefficient of variances in standardized CPUE of Pacific bluefin tuna caught by Japanese coastal longline with a nonparametric method. ISC/12/PBFWG-3/6
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_06_ichinokawaRev.pdf

Iwata, S., Oshima, K., Ichinokawa, M., Mizuno, A., Uematsu, S., Fukuda, H., Kai, M., Fujioka, K., and Takeuchi, Y., 2012, The preliminary result of stock dynamics for Pacific bluefin tuna -The descriptions of stock assessment model- ISC/12/PBFWG-3/07
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_07_IwataRev.pdf

Teo, S., and Piner, K., 2012,Preliminary population dynamics model of Pacific bluefin tuna. ISC/PBFWG-3/8
http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_08_Teo_Piner_Preliminary_PBF_population_dynamics_model.pdf

Other critical documents

Bayliff, W.H. 1994. A review of the biology and fisheries for northern bluefin tuna, *Thunnus thynnus*, in the Pacific Ocean. FAO Fish. Tech. Pap. 336/2: 244–295.

Francis RICC, 2011, Data weighting in statistical fisheries stock assessment models, Can. J. Fish. Aquat. Sci. 68: 1124–1138.

IATTC. 2012. Conservation and management measures for bluefin tuna in the Eastern Pacific Ocean. Inter American Tropical Tuna Commission 83rd Meeting, 25-29 June 2012, La Jolla, California, USA. Resolution C12-09. Available at: http://www.iattc.org/PDFFiles2/Resolutions/C12-09Conservationofbluefintuna.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2000. Report of the Pacific Bluefin Tuna Working Group Workshop, 28-30 January, 2000, Nagasaki, Japan. Available at: http://isc.ac.affrc.go.jp/pdf/ISC3pdf/ISC_03_PLENARY_07_pbt1.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2009. Report of the Pacific Bluefin Tuna Working Group Workshop, 10-17 December, 2008, Ishigaki, Japan. Annex 4.

Report of the Ninth Meeting of the International Scientific Committee for Tuna and Tuna like Species in the North Pacific Ocean, Plenary Session. 15-20 July 2009, Kaohsiung, Chinese Taipei. Available at: http://isc.ac.affrc.go.jp/pdf/ISC9pdf/Annex_4_ISC9_PBFWG_Dec08.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2010. Report of the Pacific Bluefin Tuna Working Group Workshop, 6-9 July, 2010, Nanaimo, Canada. Annex 7. Report of the Tenth Meeting of the International Scientific Committee for Tuna and Tuna like Species in the North Pacific Ocean, Plenary Session. 21-26 July 2010, Victoria, British Colombia, Canada. Available at: http://isc.ac.affrc.go.jp/pdf/ISC10pdf/Annex_7_ISC10_PBFWG_Jul10.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2012a. Report of the Pacific Bluefin Tuna Working Group Workshop, 31 Jan 7 Feb. 2012, La Jolla, California, USA. Annex 6. Report of the Twelfth Meeting of the International Scientific Committee for Tuna and Tuna like Species in the North Pacific Ocean, Plenary Session. 18-23 July 2012, Sapporo, Japan. Available at: http://isc.ac.affrc.go.jp/pdf/ISC12pdf/Annex 6 - Report of the PBF Workshop (Jan-Feb 2012).pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2012b. Report of the Pacific Bluefin Tuna Working Group Workshop, 30 May 6 June, 2012, Shimizu, Shizuoka, Japan. Annex 8. Report of the Twelfth Meeting of the International Scientific Committee for Tuna and Tuna like Species in the North Pacific Ocean, Plenary Session. 18-23 July 2012, Sapporo, Japan. Available at: http://isc.ac.affrc.go.jp/pdf/ISC12pdf/Annex%208%20%20Report%20of%20the%20PBFWG%20Workshop%20(May-June%202012)%20Formatted.pdf

Shimosea, T, Toshiyuki Tanabe, Chen, K.S.,Hsu, C.C. 2009. Age determination and growth of Pacific bluefin tuna, *Thunnus orientalis*, off Japan and Taiwan, Fish. Res. 100,134–139.

Tanaka, S. 2006, Maturation of bluefin tuna in the Sea of Japan. ISC/06/PBFWG/09

WCPFC. 2010. Conservation and Management Measure for Pacific Bluefin Tuna. The Seventh Regular Session for the Western and Central Pacific Fisheries Commission. 6-10 December, 2010, Honolulu, Hawaii. CMM 2010-04. Available at: http://www.wcpfc.int/system/files/documents/conservationandCMM%20201004%20%5BPacific%20Bluefin%20Tuna%5D%2004112011.pdf

6 *Appendix B*

Attachment A: Statement of Work for Dr. Sylvain Bonhommeau

External Independent Peer Review by the Center for Independent Experts

Stock assessment of Pacific bluefin tuna in the North Pacific Ocean

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: Pacific bluefin tuna in the North Pacific Ocean (NPO) are harvested multi-nationally primarily using purse-seine, troll and set net gear. The U.S. catches bluefin mostly in sport fishery and incidentally in the albacore troll and pole-and-line fishery. An assessment of Pacific bluefin tuna in the North Pacific Ocean was conducted by NMFS staff of the Southwest Fisheries Science Center and collaborating scientists from members of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), within the ISC's Pacific Bluefin Working Group (PBFWG) in 2012. Results of the 2012 assessment indicate that the 2010 biomass is near the lowest since 1952 (22,606 mt) and at about 3.6% of the unfished levels. Fishing mortality for 2007-09 period was high and above all calculated biological reference points; Fishing mortality increased since the last assessment period of 2002-04. Population dynamics were estimated using a fully integrated age-structured model (StockSynthesis v3.23b; SS) fitted to catch, size composition, and catch-per-unit of effort (CPUE) data from 1952 to 2011 provided by PBFWG members. Life history parameters included a length-at-age relationship from otolith-derived ages and natural mortality estimates from a tag-recapture study. The assessment provides the basis for scientific advice on the status of the Pacific bluefin tuna stock and will be the foundation for international management decisions of the Inter-American Tropical Tuna Commission and Western and Central Pacific Fisheries Commission and its Northern Committee, and domestic management decisions by the Pacific Fishery Management Council (PFMC). An independent peer review of the assessment will provide valuable feedback to the PBFWG in conducting future assessments. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have expertise, working knowledge, and recent experience in various subject areas involved in the review: tuna biology; analytical stock assessment, including population dynamics theory, integrated stock assessment models, and estimation of biological reference points; and Stock Synthesis and AD Model Builder. Scientists employed by or have significant interactions with the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC), and the Secretariat of the Pacific Community (SPC), should not be considered as reviewers. Scientists associated with the ISC also should be excluded as reviewers. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a "desk" review of the necessary documentation of the current assessment of Pacific bluefin tuna. Therefore, no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

<u>Prior to the Peer Review</u>: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, whom forwards this information to the NMFS Project Contacts no later than the date specified in the Schedule of Milestones and Deliverables. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

<u>Pre-review Background Documents</u>: Two weeks before the peer review, the NMFS Project Contact must send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports of the current assessment and sensitivity analyses to be peer reviewed. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Documents will include: The PBFWG stock assessment report and some working papers. **Please note that supporting documentation for the review is confidential and reviewers are not to circulate these documents.**

<u>Desk Review</u>: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

<u>Contract Deliverables - Independent CIE Peer Review Reports</u>: Each CIE reviewer shall complete an independent peer review report addressing each ToRs in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contacts in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than 7 June 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu.

Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

6 May 2013	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
15 May 2013	NMFS Project Contact sends the CIE Reviewers the report and background documents
16 – 31 May 2013	Each reviewer conducts an independent peer review as a desk review
7 June 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
21 June 2013	CIE submits the CIE independent peer review reports to the COR
28 June 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on substitutions. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) Each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) Each CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COR
NMFS Office of Science and Technology,
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc. 10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

Roger W. Peretti, Executive Vice President
Northern Taiga Ventures, Inc. (NTVI), 22375 Broderick Drive, Suite 215, Sterling, VA 20166
RPerretti@ntvifederal.com Phone: 571-223-7717

Key Personnel - NMFS Project Contact:

Dr. Steve Teo
Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037
Steve.Teo@noaa.gov Tel: 1-858-546-7179, Fax: 1-858-546-7003

Dr. Kevin Piner
Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037
Kevin.Piner@noaa.gov Tel: 1-858-546-7179, Fax: 1-858-546-7003

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background and Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

Stock assessment of Pacific bluefin tuna

1. Review the assessment methods to provide recommendations on how to improve its application, and/or recommend other methods that would also be appropriate for the species, fisheries, and available data.

2. Evaluate the assessment model configuration, assumptions, and input parameters (fishery, life history, and spawner recruit relationships) to provide recommendations on how to improve: the use of data, specification of fixed input parameters, and specification of model configuration.

3. Provide recommendations on improving the treatment of assumptions (e.g. sensitivity analyses) and description of uncertainty in estimates of stock dynamics and management quantities (e.g. reference points).

4. Provide recommendations on improving the adequacy, appropriateness, and application of the methods used to project future population status.

5. Suggest research priorities to improve the stock assessment including data, life history and modelling.

Please note that supporting documentation for the review is confidential and reviewers are not to circulate these documents.

7 Appendix C

Grammatical comments

General comments
I find the report generally very well-written and clear. There are, however, several places where it is repetitive. Also, clarity could be enhanced with small changes to improve the consistency of terms, tense, usage of acronyms, and other small grammatical corrections.

Pg 2 Table of Contents
Use lower case "5.2 Stock assessment results"
Page number is "0" for 8.0 Tables and Figures
Pg 3 Executive Summary
Line 16 "... PBF landing records from coastal Japan date back as early as 1804 ..." should read "...PBF landing records date back as early as 1804 from coastal Japan ..."
Line 19 Use a comma instead of a period for "...and 12,000 mt in the EPO..."
Line 21 Use a comma at "By 1952, ..."
Line 24 "While a suite of fishing gears catch PBF ..." should read "While a suite of fishing gears are used to catch PBF ..."

Line 26 Use a comma at "... and since the early 1990s, the catch ..."
Line 33 Use a comma at " ...data from 1952 to 2011, ..."
Line 33 Acronym ISC undefined
Line 37-38 Should read "A total of 14 fisheries were defined based on country/gear stratification for use in the stock assessment model."
Line 38 Should read as "... of catch and, when available, size composition were used as inputs into the model ..."
Line 41-42 Should read as " ... measures of the relative abundance of the populations."
Line 44 Inconsistent use of the terminal comma. Here, it is used, but previously, it was not. Please choose one convention and use throughout the manuscript.
Line 47 Should read as "The PBFWG recognized the uncertainties ..."
Pg 4
Line 4 Should read as "... of data that were deemed reliable, there was a general agreement ..."
Line 5 Long sentence. Cut at "...key model results. Long-term fluctuations..."
Line 7 Should read "...and SSB has been declining for over a decade in recent years. However, there is no evidence..."
Line 10 CMM acronym is previously undefined. Also, should read "CMMs" not "CMMS"
Line 18 Should read "...SSB were estimated ..."
Line 21 "... (the base period for the current WCPFC conservation and management measure 2010-04)..." is basically a repeat of Pg 4 Line 9/10. I would remove the text in parentheses.
Line 22 Should read "... 4%, 17%, 8%, 41% and 10% ..."
Line 24 Once an acronym has been defined, use it consistently, i.e., use PBF instead of Pacific bluefin tuna.
Line 29 Replace "spawning biomass" with "SSB" and "Pacific bluefin tuna" with PBF
Line 33 Should read "Future recruitment levels used in the projections ..."
Line 46 If this retains the original meaning, please use a "/" between "increase/recover".
Pg 5
Line 8 Should read "Model estimates of the 2010 SSB are at or near..."
Line 9 Long sentence. Please cut as "... their lowest level. SSB has been declining..."
Lines 19-22 Should read "Recently, conservation and management measures of the WCPFC1 and IATTC2, effective in 2011 and 2012, respectively, and combined with additional voluntary domestic regulations of the Japanese that aimed to reduce fishing mortality, are expected to contribute to improvements in PBF stock status, if properly implemented and enforced."
Line 23 Should read "...it should be noted that the implementation ..."
Line 29 Should read "Until which time that a decision..."
Line 30 Use the acronym "BRPs" as it has been previously defined.
Pg 8
Figure 4 lower panel, y-axis should read "Relative SSB"
Line 2 "combinations"
Pg 9
Line 2 "combinations"
Pg 10
Figure 6 upper panel, y-axis should read "SSB" for consistency with Figure 4. Also, "SSB" can be used in the legend as it is defined in the figure caption.
Line 1 Should read "Spawning stock biomass (SSB) (mt) ..."

Lines 2-3 Should read “Dashed red lines indicate the 80% confidence intervals and the solid red line indicates the median time series estimated from ...”
Pg 12
Units are missing in both the plots and caption.
Line 1 Should read “Figure 8. Recruitment and expected spawning stock biomass (SSB) and total catch from 2011 to 2030, based on future projections.”
Line 3 EPO and WPO acronyms should be spelled out before use in each caption.
Pg 13
Line 2 Should read “... the stock assessment report for the different...”
Line 2 CV is an undefined acronym
Define the acronyms used in the table in the caption, i.e., CPUE, LL, CV
Pg 14
Table 3 caption, Line 2. Acronyms should be defined before use, i.e., “Pacific bluefin tuna (PBF) relative to ...” and “ration of spawning stock biomass (SSB) ...” Table 3 caption, Line 3-4 Should read “... SSB (mt) in 2010 for 20 model configurations (runs).”
Pg 15
Line 16 A definition of CMM should be given here as the first definition of an acronym for the body of the report.
Line 17 Long sentence, cut as “...(WCPFC 2010 – CMM2010-04). The IATTC adopted ...”
Pg 16
Line 8 Define the acronym for Pacific bluefin tuna when it is first used in the Introduction and then use the acronym consistently throughout the report.
Line 14 There is an extra space before the first period.
Line 20 Should read “Spawning in the area around the Ryukyu ...” Line 30 Should read “between 20^{o} N to 40^{o} N ...”
Line 35 Should read “...immature age-1 to -3 fish in the ...”
Pg 17
Line 1 There is a space missing “(Figure 2-3)”.
Line 11 Remove comma after “...variation in spawning”
Line 23 Remove “the“ from “...the Pauly’s equation ...”
Line 30 Should read “...are relatively low ...”
Line 47 This sentence, which is about fishing gear, does not properly introduce the rest of the paragraph, which is about the historical fishing grounds of the US.
Pg 18
Line 1 Should read “...developed in the traditional...”
Lines 17-18 I recommend using the Latin names of species in parentheses after their common names.
Line 23 Should read “... with the 2011 catch at 670 mt ...”
Lines 23-24 Should read “PBF fishing grounds have been located around Jeju Island with fishing occurring during March and April for the past 5 years.”
Line 31 First use of “GRT“ acronym, thus, it should be spelled out in full.
Line 34 Please add a comma “...landings started to increase sharply, mostly due...”
Line 36 Please give the year in which the decline in catch to 1000 mt was observed.
Lines 42-43 Should read “For the current assessment, there were several major differences of the input data and structural assumptions as compared to the base case of the 2010 assessment.”
Line 46 Please delete “in the 2010 base case“ as it is repetitive.
Pg 19

Line 3 Should read “Selectivity of the Japanese ...
Line 7 Should read “...made in both the current and 2010 assessments.”
Line 9 Use lower case for “(see Sections ...”
Line 26 As you state that years stated are fishing years, unless otherwise defined, it is not necessary to include “(fishing years)” here. Please delete.
Line 31 Should read “PBFWG set the starting year to 1952 as catch-and-effort data from Japanese longline fleets and ...”
Line 37 I suggest calling them “fleets“, with a lower case, hereafter, as there is a lot of inconsistency in capitalization for this word in the rest of the report. Use a capital for the proper noun usage, i.e., Fleet 1, Fleet 2, and a lower case when you are referring to the fleets in general.
Line 38 Should read “... to the gear, the consistency of size ...”
Line 42 Add “fishery” after “US sport”
Line 46 Please consistently use past tense for you methods throughout the report, i.e., this line should read “...purse seine fishery were used to represent this fleet.”
Pg 20
Line 1 Add “the” in front of “Pacific”.
Line 2 Tense consistency. Change to “They were defined ...”.v Line 5 Tense consistency. Change to “The fleets were separated ...”.
Line 6 Please adjust the hyphens between length-weight and set-nets so that there are no spaces in between.
Line 8 Replace “misfits“ with “differences“.
Line 10 Should read as “...based on season. Fleet 9 in this assessment...”.
Lines 20-25 You have previously defined the fleets, therefore, it is repetitive and unnecessary to do so again here.
Line 30 Please add an “and” between “...before 1994, and Japanese purse seine...”
Line 39 Please use hyphens consistently, i.e., “catch-and-effort data”, as used previously.
Line 40 Please add a comma “...except for Series S4, which...”.
Lines 41-44 Again, the fleets do not need to be redefined here.
Line 46 Tense consistency. Change to “...this stock assessment used ...”.
Line 47 Please indicate which years you are referring to instead of “past periods” and “recent periods”.
Pg 21
Line 14 Please remove commas, i.e., “Run (base case) from which stock status and management advice was developed was based...”.
Line 27 Tense consistency. Change to “The time series was split ...”.
Line 30 Should read as “which was used to standardize these targeting...”.
Line 32 Replace “because” with “as”, i.e., “...coastal longline fishery as logbook data...”.
Lines 44-45 Should read as “Due to these unresolved issues, this index was not used in the base-case model.”
Pg 22
Lines 2-3 and throughout “Prefectures” does not need capitalization.
Line 6 Replace “because” with “as”, e.g. “...as most trollers make ...”, and “As effort data in Kochi ...”. Line 9 Please add “the”, i.e., “...was applied for the Nagasaki prefecture because effort data in the Nagasaki Prefecture...”.
Line 18 Change “S6 series” to “S6 inde”.
Lines 32-33 Spell out GLM and GLMM in their first usage.
Line 46 Should read “Due to unresolved issues concerning the representativeness of these data to reflect abundance, this index...”.

Pg 23
Line 7 Should read “Pacific bluefin tuna”
Line 17 Define FL before using the acronym, but use the acronym thereafter.
Lines 22-23 Use hyphens to separate numbers, as above, e.g. “Fleets 1-14”.
Line 32 Does “WG” refer to “PBFWG”? If so, please use PBFWG to avoid confusion. If not, please define WG more clearly and spell it out in full in this first usage.
Pg 24
Line 19 Should read “were available from 1987-2010, except 1990, when there was no catch.”
Lines 26-28 Should read “Size composition data, computed primarily from weight, from the Japanese purse seiners off the Pacific coast of Japan were collected at the Tsukiji market and several unloading ports in Tohoku region between the 1950s and 1993.”
Pg 25
Lines 24-28 Should read “While the average length of the catch fluctuated around 75 cm (1-year old fish) before the mid-1980s when the US Pacific bluefin tuna target fishery was operating, there has been a shift towards larger fish (mean size of ~85 cm; 2-year old) in the late 1990s and 2000s, as the Mexican purse seine fishery has targeted Pacific bluefin tuna for farming operations.”
Lines 44-45 Should read “The size composition data, based on weights, showed a large peak at ~10 kg with a long tail extending to 250 kg...”
Lines 45-46 Should read “Given the model structure, preliminary analysis indicated that poorly fitted size composition estimates from this fleet strongly influenced...”
Pg 26
Line 9 Once an acronym has been defined, e.g. Stock Synthesis (SS), use the acronym throughout the rest of the report.
Line 43 Should read “...CV for age-3+ fish was...”
Pg 27
Lines 1-2 Should read “...bluefin tuna, the age of A2 was manually tuned to optimize the model fit...”
Line 3 Should read “...manually tuned to optimize the model fit in...”
Line 29 Replace “recording“ with “records”.
Pg 28
Line 1 Be consistent throughout the report with the use of hyphens, i.e., use hyphens when using age-0, age-1, etc as adjectives of “fish”; otherwise, do not use the hyphens.
Line 6 Be consistent with the use of the subscript, e.g. R_0 and R_0.
Line 17 Should read “...depending on the run...”
Lines 18-19 Should read “...recruitment deviations in 1942–1951 represent deviations from a stable age structure (ages 1-10) in 1952, i.e., the start year of the stock assessment.”
Line 20 Should read “... and expectations of stock levels for 2010 derived from the stock-recruitment (S-R) relationship. A full bias...”
Line 22 Be sure to include the period after “et al.” here and for all references.
Line 23 Period missing from the end of the sentence.
Line 27 Should read “h tends to be poorly estimated due to the lack...”
Pg 29
Line 17 Define the acronym for fishing mortality rates here, as it is the first use.
Line 31 There is an extra space between the end of the sentence and the period.
Line 32 Should read “...patterns were estimated using length composition data for all fisheries except ...”

Pg 30
Line 5-6 “This assumption meant that at least one of the fisheries sampled from the entire population after a specific size.
Line 7 Should read “This is a strong assumption that was evaluated in a separate analysis...”
Lines 9-10 Add commas “This assumption, along with the observed sizes and life history parameters, sets an upper bound to the population size.”
Line 12 Should read “...which were both estimated ...”.
Line 16 Should read “...or were fixed to a small...” Lines 17-18 Should read “... SS to decay the selectivity of small and large fish ...”
Line 20 Replace “hit“ with “reached”
Line 21 Remove comma after “i.e. ” here and throughout the report as you do not use a comma after i.e. or e.g. previously in the report.
Lines 28-29 Should read “In addition, Fleets 6 and 13 and Fleets 5 and 12 were similar in terms of fishing areas and sizes of fish caught.”
Pg 31
Line 2-3 Rephrase as “This resulted in a 10 cm rightward shift of the selectivity curve...”
Line 5 The use of “Other“ here in reference to the fishing areas and on the previous page in reference to the fishery is confusing. If it is capitalized as a proper noun, the term should have a clear definition.
Line 8 Add a comma “...the fleets, which indicated...”.v Lines 13-16 “Catchability (q) was estimated assuming that each index of abundance was proportional to the vulnerable biomass/numbers with a scaling factor of q that was assumed to be constant over time. Vulnerable biomass/numbers depended on the fleet–specific selection pattern and underlying population numbers-at-age.”
Line 23 Add an “a” before “recruitment penalty”, i.e., “compositions, and a recruitment penalty.”
Line 34 Change to “...constrains the estimates...”.
Line 40 Change to “...deviation approaches σ_R.”
Pg 32
Line 6 Delete comma after “e.g.”
Line 25 Add commas, i.e., “...composition data, except for Fleets 6, 13 and 14, were fitted...”.
Line 36 Again, if WG refers to PBFWG, please use PBFWG for consistency.
Line 36 Change to “In this analysis, up to eight years of data were removed and the WG examined changes in the estimates of SSB and recruitment.”
Pg 33
Line 4 Change to “...assessment, and categorized them into four...”
Line 9 Remove “of”, i.e., “...developing the Representative Run...”
Line 10 Add commas, i.e., ”...sets, etc.), but results...”
Line 30 Change comma to a semicolon, i.e., ”...to the model; improving the fit...”.
Lines 31-32 Rephrase as “Sensitivity runs were performed by fitting S1, S9, or both indices.”
Line 39 Add comma, i.e., “Therefore, two alternative...”.
Lines 39-43 Repetitive. This was said on Pg 32.
Line 48 Replace “misfit to the size composition data” with “poorly fit size composition data”.
Pg 34

Line 2 Add “ the SS model”, i.e., “not fitting the SS model to the size composition components.”
Line 27 Add hyphens, i.e., “numbers-at-age”.
Line 34 Here, you hyphenate “log-normal”, whereas previously, you use “lognormal”. Please choose one convention to use throughout the report.
Pg 35
Line 18 Add “the”, i.e., “(since the 2012 fishing season) and Japan (since the 2011 fishing season).”
Line 35 “SSB” instead of “spawning stock biomass”.
Line 41 Add “%“ after each number, i.e., “4%, 17%, 8%, 41%, and 10%“.
Pg 36
Line 10 Add “the”, i.e., ”...fit for the Japanese longline index...”.
Line 11 Change to “...were relatively poor (rmse = 0.46 and 0.35, respectively)”.
Lines 26, 28, and 39 Add hyphen to “well-estimated”.
Line 29 Add comma and “%”, e.g. “(1% and 11%, respectively)”.
Line 31 Spell out, i.e., “...using five parameters...”.
Line 33 Change “misfits” to “differences in fit”.
Line 39 Add “the”, i.e., “... for both the early and the late periods...”.
Line 40 Add “%” and correct spelling, i.e., “...(CV = 50%, 36%, and 505%, respectively).”
Line 42 Change “a lot of information” to “enough information”.
Pg 37
Line 2 Add “%”, i.e., “1% to 10%”.
Line 3 Add “%”, i.e., “146% to 198%”.
Line 22 It is unnecessary to redefine SSB here.
Line 35 It is not necessary to add “(since 1990)” here, as you give the specific years later in the sentence. Please remove.
Line 40 Please be consistent with the spacing around mathematical operators, e.g. in this line you use “CV = 31%”, but in the previous line you use “CV=14%”. Please choose one convention to use throughout the report.
Line 46 Define “spawner-recruit” acronym the first time you use this phrase in the body of the report.
Pg 38
Line 1 As you use hyphens between words for similar terms, such as “catch-at-age”, I would suggest using hyphens between words for, i.e., “mortality-at-age” and “fish-at-age” here and throughout the report.
Line 6 Add “and” and hyphens, i.e., “...ages-0, -2, and -3 fish were 0.59, 0.56, and 0.26, respectively.”
Line 7 Again, please have consistent use of hyphens for adjectives here and throughout, e.g. “ age-4+ fish”.
Line 34 “Conservation Management Measure” and “biological reference points” have previously been defined by acronyms. Please use the acronyms.
Lines 33-36 Should read “In addition, estimates of F2007-2009 (current F) or F2002-2004 (reference year by current WCPFC Conservation Management Measure) were calculated relative to a subset of F-based biological reference points (Fmax, Fmed, F20%), the estimated depletion ratio (SSB2010 relative to SSB0), and SSB2010 (Table 5-5).”
Line 40 It is not necessary to redefine BRP here. Please use just the acronym.
Pg 39
Line 7 Section titles do not need periods. Please remove here and throughout the report.

Line 8 It is not necessary to redefine SSB here. Please use just the acronym.
Line 9 Replace "provided" with "gave".
Line 11 Replace "Recruitments" with "Recruitment levels
Line 13 Add an "an", i.e., "an increasing CV...".
Lines 20-21 Change to "Runs 4 and 8 fit well the observed S1 index for the last five years, relative to Run 10 as Run 10 ..."
Line 22 Spell out number, i.e., "... (two log-likelihood units for S1)."
Line 27 Add "the", i.e., "...given to the F3 size composition..." and "...given to the F3 composition...".
Line 27 Capitalize "Run", i.e., "...(Run 1; using EffN-F3 #1)..."
Line 29 Add "the", i.e., "...improved the model fit...".
Line 34 Change to "...estimated recruitment levels were 17% and 4% lower..."
Pg 40
Line 1 Add "%", i.e., "...34% and 8.7% lower...".
Line 12 Delete the "s", i.e., "The recruitment estimates in...".
Line 16 Spell out the number, i.e., "...(< two log-likelihood units)."
Line 22 If correct, please change to "The model, which assumed a lower steepness parameter (h = 0.8) than the Representative Run,". If not correct, please specify to what the model is being compared.
Line 29 Please change to ".... well (these Fleets catch mainly age 0-1 fish). The growth curve..."
Line 47 Please be consistent with the use of subscripts, i.e., here you use "F2007-2009", whereas previously you used "$F_{2007–2009}$". Please choose one convention to use throughout the report.
Pg 41
Line 7 Please change to "This is reflected in the 90% confidence intervals observed for the projections with catch limits as they are wider than in those without catch limits (Figure 5-28)."
Line 9 Remove comma, i.e., "...runs without catch limits when fishing...".
Line 17 It is not necessary to explain the $F_{2007–2009}$ or $F_{2002–2004}$, as you have done this several times previously, i.e., "...candidate F-based BRPs (Fmax, $F_{0.1}$, Fmed, Floss and $F_{10\%–40\%}$) to $F_{2007–2009}$ and $F_{2002–2004}$ are shown in Table 5-4."
Line 31 This has been stated several times already and is not necessary here, "(the base period for the current WCPFC conservation and management measure 2010-04)"
Line 32 Add "%" after each value, i.e., "...4%,17%, 8%, 41% and 10%...".
Line 35 BRPs have already been defined. Use the acronym only.
Line 38 Replace "spawning biomass" with "SSB".
Line 42 Replace "recruitments" with "recruitment levels".v Line 9 If correct, please change to "... increase or recover ...".
Line 21 Add a "the", i.e., "...estimates of the 2010 SSB are...".
Section 6.2 Outlook is almost exactly the same as what has just been written above, starting from the second paragraph under Section 6.1 Current stock status. Please remove one of these.
Pg 43
Line 3 Please do not redefine BRPs. Use the acronym only.
Line 7 Please change to "...WCPFC[3] (effective as of 2011) and IATTC[4] (effective as of 2012)...".

Line 8 “conservation and management measures” have already been defined as “CMMs” in the body of the report. Please use the acronym.
Line 8 Change to “... combined with additional voluntary domestic regulations of the Japanese that aimed to reduce fishing mortality...”.
Line 18 Change to “... (as of 2010)...”.
Line 18-27 This is a repetition of what has just been written. Delete.
Pg 49
Please delete the long break between references that starts on this page.
Table 3-1
Please be consistent with capitalization within the table, especially regarding the Corresponding Fisheries column, e.g. “Japanese longline”, “Japanese set net“, “Japanese tuna purse seine in Sea of Japan”, etc. Also, in the Data Quality column, “Raw measurement”.
Please correct the spelling of “Standardized” in the Data Quality column.
Corresponding Fisheries column, Pg 1, “Japanese coastal longline conducted in spawning area and season”.
Table 3.4
Caption should read “... size composition input data...”.
F2 Use hyphens for “catch-at-size”.
F2 Change to “Length composition of Korean PS not included. As fishing ground ...”.
F3 Add a period.
F4 Use hyphens for “Catch-at-size”.
F4 Change to “ ... were reviewed again and catch-at-size were re-constructed.”
F4 Should read “ 1980s“ without apostrophe.
F5 Should read “many landing ports”. Add a period after “method”.
F8 Add a period at the end.
F9-10 Should read “regions”. F11 Add a period.
F12 Use lower case for “fair” and “good”.
F13 Should read “ Data and share selectivity for early period of EPS PS not fit.”
F14 Should read “Includes”. Add a period at the end.
Table 4-1
Remove periods after “lambda=x”, or “weight=x”.
Table 4-2
Caption Add an “and”, i.e., “... mortality, steepness, and von Bertalanffy growth...”.
Natural Mortality, Column Assumption Correct spelling of “Higher”.
Steepness Parameter, Row Run1, “Fix” should be capitalized.
Table 5-4
Replace “(F0709 or F0204”‘ with “(F2007-2009 or F2002-2004)” in caption and table.
Table 5-5
First define SSB before using the acronym in the caption.
Table 5-6
Capitalize “Point estimation”, “Terminal year (2010)”, “Historical median”, and “Historical minimum”.
Fig 2-1
Legend Beware of the text wrap which breaks up the word “the”.
Fig 2-2
Legend Replace “imatured” with “immature”.
Fig 2-5
Caption Use lower case for “(calendar year)”.

Fig 3-1
Caption Delete the extra period at the end of the sentence.
Fig 3-2
Caption Use lower case for " ...(a) indices from...", "... (b) index...", and "... (c) other...".
Fig 3-3
Caption Change to "... by sample size input ...".
Caption Change to " X-axis is fork length...".
Caption Capitalize "Fleet 7 and 14".
Fig 3-4
Caption Change to "size composition input data".
Fig 5-1
Legend Capitalize "Median". Use lower cases for "point estimation", "absolute value", and "relative value".
Fig 5-2
Y-axis labels are missing.
Fig. 5-3
Legend Capitalize "Representative Run". Use lower case for "likelihood" and "jitter".
Missing y-axis labels.
Fig. 5-9
Caption Use "spawning stock biomass" instead of "spawning biomass" for consistency.
Fig. 5-11
Values missing from plot.
Y-axis label Use lower case for "Number of fish (x 1,000)".
Fig. 5-12
Caption Space missing between the figure number and the start of the text.
Caption Define the acronym for spawning stock biomass (SSB) as SSB is used in the figures.
Fig. 5-13
Caption Define the acronym for spawning stock biomass (SSB) as SSB is used in the figures.
Fig. 5-14
Caption Define the acronym for CV and CPUE.
Caption, Line 2 Use capital and a space for "Run 4".
Caption, Line 3 A space is missing between " ...panel). Residuals...".
In the Fig. 5-4 caption, you have used "observed - expected" and here you spell out "minus". Please choose one convention to use throughout the report.
Caption, Line 3 Please capitalize "Representative Run".
Fig. 5-15
Caption Define the acronym for spawning stock biomass (SSB) as SSB and spell out CV.
Fig. 5-16
Caption Define the acronym for spawning stock biomass (SSB) as SSB is used in the figures.
Fig. 5-17
Caption Define and spell out CPUE in the caption as CPUE is used as y-axes labels, i.e., " Expected abundance trends (line) and observed indices (line and circle) defined by Catch Per Unit Effort (CPUE) ...".
Fig. 5-18

Caption Define and spell out CPUE in the caption as CPUE is used as y-axes labels, i.e., " Expected abundance trends (line) and observed indices (line and circle) defined by Catch Per Unit Effort (CPUE) ...".
Fig. 5-20
Caption Define the acronym for spawning stock biomass (SSB) as SSB is used in the figures.
Fig. 5-21
Caption Define and spell out CPUE in the caption as CPUE is used as y-axes labels, i.e.," Expected abundance trends (line) and observed indices (line and circle) defined by Catch Per Unit Effort (CPUE) ...".
Fig. 5-24
Caption Define the acronym for spawning stock biomass (SSB) as SSB is used in the figures.
Fig. 5-25
Caption Define the acronym for spawning stock biomass (SSB) and define "M", i.e., "...natural mortality (M)...".
Fig. 5-26
Caption Define the acronym for spawning stock biomass (SSB) and define "h", i.e., "...steepness (h)...".
Fig. 5-27
Caption Define the acronym for spawning stock biomass.
Caption, Line 2 Remove "(", i.e., "... studies: ISC08/PBFWG01/08...".
Fig. 5-28
Y-axis labels missing, no units.
Caption Use "spawning stock biomass" instead of "spawning biomass" and define the acronym, i.e., " spawning stock biomass (SSB)".
Caption, Line 2 Fix subscripting for F2007-2009 as the "F" is subscripted as well.
Caption, Line 3 Spell out EPO and WPO.
Fig. 6-1
X-axis "Age" should be capitalized
Legend Subscript the years after "F", if possible.

8 Appendix D

Here are all the scripts used to extract the data and plot the figures. Comments are welcomed: send email at: `sylvain.bonhommeau@ifremer.fr`

```
##################################################################
### PURPOSE : Script to extract the output of the SS3
###           for the PBF stock assessment and plot the figures
###           of the review report
### INPUTS  : SS3 files
### OUTPUTS : Figures
### MISC.   :
##################################################################

###########################
### LOAD the packages  ###
###########################

library(r4ss)
library(ggplot2) ## because ggplot is way nicer than r4ss plots ;)
library(RColorBrewer)
library(reshape)
require(psych)
require(gridExtra)
#update_r4ss_files() ### there seems to have a bug with the new SS_output...

###########################
### GET the data  ########
###########################
setwd('~/Desktop/PBT_assessment/SS3')

replist1 <- SS_output(dir=getwd())

#####################################################
### FIGURE 1 and 2: Catch trend per fleet  ######
### (absolute and relative to total values)######
#####################################################

### Get the catch data
catch         <- SSplotCatch(replist=replist1, subplot=10, plot = F, print = F, verbose = FALSE)
catch      <- catch$totobscatchmat
catch2     <- melt(catch, measure.vars=colnames(catch)[1:14])
catch2$Year <- floor(catch2$Yr)
catch3     <- ddply(catch2, .(Year,variable), function(x) sum(x$value))
colnames(catch3) <- c("Year", "Fleet", "Catch")

### Figure 1
colors <-  brewer.pal(11,name="Spectral")
colors <- colorRampPalette(colors)(14)
```

```
p     <- ggplot(catch3, aes(x=Year,y=Catch))
p+geom_area(aes(fill=Fleet, group = Fleet))+scale_fill_manual(values=colors)+labs(x="",y="Catch (mt)")+ theme(axis.text.x = element_text(size=20),axis.text.y = element_text(size=20),axis.title.y = element_text(size=24))
dev.copy2pdf(file="../Catch_fleet.pdf")

catch4 <- ddply(catch2, .(Year), function(x) sum(x$value))
catch5 <- ddply(catch3, .(Year,Fleet), function(x) x$Catch/catch4$V1[which(catch4$Year==unique(x$Year))]*100)
colnames(catch5) <- c("Year", "Fleet", "Catch")

### Figure 2
p <- ggplot(catch5, aes(x=Year,y=Catch))
p+geom_area(aes(fill=Fleet, group = Fleet))+scale_fill_manual(values=colors)+labs(x="",y="Catch (%)", size=20)+ theme(axis.text.x = element_text(size=20),axis.text.y = element_text(size=20),axis.title.y  = element_text(size=24))
dev.copy2pdf(file="../Catch_fleet2.pdf")

###################################
### FIGURE 3: Catch Season  ######
###################################

catch_season           <- catch2
catch_season$season      <- (catch_season$Yr-floor(catch_season$Yr))*4
catch_season_tot        <- ddply(catch_season, .(season), function(x) sum(x$value))
catch_season_tot$percent <- catch_season_tot$V1/sum(catch_season_tot$V1)*100

catch_season_tot[,1]     <- c("July-Sep", "Oct-Dec", "Jan-Mar", "Apr-June")

p <- ggplot(catch_season_tot, aes(x=season, y=percent))
p+geom_bar()+labs(x="Quarter", y="Percentage of catch over 1952-2010")+ theme(axis.text.x = element_text(size=20),axis.text.y = element_text(size=20),axis.title.y  = element_text(size=24))
dev.copy2pdf(file="../Catch_season.pdf")

###################################
### FIGURE 4: Size distribution ##
### in the catch               ##
###################################
#To be fully check because I'm not sure about how to raise the sample size data...
bin <- ddply(replist1$sizedbase, .(Fleet,Bin), function(x) data.frame(obs=sum(x$Obs),numb=sum(x$N)))
bin$bin <- bin$obs/bin$numb
bin    <- bin[-which(bin$Fleet%in%c(7,14)),]
size    <- ddply(bin, .(Bin), function(x) sum(x$bin))
colnames(size) <- c("number", "bin")
size$tot <- "Tot"
```

```
p=ggplot(size, aes(x=number, fill=tot))
p+geom_density(adjust=0.4)+scale_fill_manual(values=brewer.pal(3,name="Set1")[1])+l
abs(x="Size (cm)",y="Frequency")+ theme(axis.text.x =
element_text(size=20),axis.title.x = element_text(size=24),axis.text.y =
element_text(size=20),axis.title.y =
element_text(size=24))+scale_x_continuous(breaks=seq(0,300,20))
dev.copy2pdf(file="size_comp.pdf")

######################################################
### FIGURE 5-6-7: Impact of natural mortality on ##
### SSB, R, and Fs ##
### M is set it to 0.15 for older ages ##
######################################################
M <- c(1.6, 0.386, rep(0.25,18))

### Get the Fs-at-age for the representative run
tt <- replist1$Z_at_age[which(replist1$Z_at_age[,3]%in%c(2007,2008,2009)), 4:23]
minus <- function(x){x-M}
tt2 <- t(apply(tt,1,minus))
tt3 <- apply(tt2, 2, geometric.mean)

### Get the Fs-at-age for the the mortality test run
M <- c(1.6, 0.386, rep(0.15,18))
replist2 <- SS_output(dir=paste(getwd(),"/test_mortality", sep=""))
ttM <- replist1$Z_at_age[which(replist1$Z_at_age[,3]%in%c(2007,2008,2009)),
4:23]
minus <- function(x){x-M}
ttM2 <- t(apply(ttM,1,minus))
ttM3 <- apply(ttM2, 2, geometric.mean)
sum_F <- as.data.frame(rbind(cbind(M=0.25, age=0:19, F=as.numeric(tt3)),
cbind(M=0.15, age=0:19, F=as.numeric(ttM3))))

### Get the SSB for M=0.25 (PBFTWG)
SSB <- replist1$derived_quants[3:61,2]
SSB_up <- SSB+qnorm(0.975)*replist1$derived_quants[3:61,3]
SSB_low <- SSB-qnorm(0.975)*replist1$derived_quants[3:61,3]
### SSB for M=0.15 (Whitlock et al. 2012)
SSB_M <- replist2$derived_quants[3:61,2]
SSB_M_up <- SSB_M+qnorm(0.975)*replist2$derived_quants[3:61,3]
SSB_M_low <- SSB_M-qnorm(0.975)*replist2$derived_quants[3:61,3]
sum_SSB_M <- as.data.frame(rbind(cbind(M=0.25,year=1952:2010,SSB=SSB,
SSB_up=SSB_up, SSB_low=SSB_low),cbind(M=0.15,year=1952:2010,SSB=SSB_M,
SSB_up=SSB_M_up, SSB_low=SSB_M_low) ))

### Get the R for M=0.25 (PBFTWG)
R <- replist1$derived_quants[64:122,2]
R_up <- R+qnorm(0.975)*replist1$derived_quants[64:122,3]
R_low <- R-qnorm(0.975)*replist1$derived_quants[64:122,3]
### Get the R for M=0.15 (Whitlock et al. 2012)
```

```
R_M      <- replist2$derived_quants[64:122,2]
R_M_up   <- R_M+qnorm(0.975)*replist2$derived_quants[64:122,3]
R_M_low  <- R_M-qnorm(0.975)*replist2$derived_quants[64:122,3]
sum_R_M  <-  as.data.frame(rbind(cbind(M=0.25,year=1952:2010,R=R,  R_up=R_up,
R_low=R_low),cbind(M=0.15,year=1952:2010,R=R_M,                    R_up=R_M_up,
R_low=R_M_low) ))


### Plot the SSB sensitivity
p_SSB=ggplot(sum_SSB_M, aes(x=year, y=SSB, colour=factor(M), fill=factor(M)))+
geom_line(size=1.5)+geom_ribbon(aes(ymin=SSB_low,  ymax=SSB_up),  alpha  =  0.4,
colour=NA)+labs(x="",y="SSB         (mt)")+         theme(axis.text.x            =
element_text(size=20),axis.title.x       =      element_text(size=24),axis.text.y    =
element_text(size=20),axis.title.y  = element_text(size=24))

### Plot the R sensitivity
p_R=ggplot(sum_R_M, aes(x=year, y=R, colour=factor(M), fill=factor(M)))+
geom_line(size=1.5)+geom_ribbon(aes(ymin=R_low,    ymax=R_up),    alpha   =   0.4,
colour=NA)+labs(x="",y="R        (1000's)")+        theme(axis.text.x            =
element_text(size=20),axis.title.x       =      element_text(size=24),axis.text.y    =
element_text(size=20),axis.title.y  = element_text(size=24))

### Plot the Fs sensitivity
p_F          =          ggplot(sum_F,          aes(x=age,          y=F,
colour=factor(M)))+geom_line(size=1.5)+labs(x="Age",y="F          (year-1)")+
theme(axis.text.x         =         element_text(size=20),axis.title.x         =
element_text(size=24),axis.text.y       =      element_text(size=20),axis.title.y    =
element_text(size=24))

pdf(file="../SSB_M.pdf")
p_SSB
dev.off()

pdf(file="../R_M.pdf")
p_R
dev.off()

pdf(file="../F_M.pdf")
p_F
dev.off()
```